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Original article

Management of combined anterior or posterior cruciate ligament and posterolateral corner injuries: A systematic review

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ABSTRACT

Background: Combined injuries to the posterolateral corner and cruciate ligaments are uncommon. The heterogeneity of injury patterns in many studies complicates the assessment of outcomes.
Objective: To assess the prognosis and functional outcomes after surgery for combined injuries to the posterolateral corner and to the anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL).
Material and methods: We systematically reviewed the literature for articles reporting outcomes 1 year or more after surgery for combined injuries to the posterolateral corner and ACL ($n = 4$) or PCL ($n = 9$). Patients with bicruciate injuries were not studied.
Results: Overall, 65% of patients were IKDC A or B after surgery. The mean Lysholm score improved from 67 to 90. Mean time to surgery was 4.43 months in the group with ACL tears and 18.4 months in the group with PCL tears, and mean follow-up was 34.4 and 40.7 months in these two groups, respectively. In the groups with ACL and PCL tears, the proportions of patients classified as IKDC A or B at last follow-up were 81.6% and 81.0%, respectively, whereas 88% and 99% of patients, respectively, were IKDC grade C or D before surgery. The mean Lysholm score improved from 77 to 92 in the group with ACL tears and from 65 to 89 in the group with PCL tears. Improvements in laxity ranged from 28% to 79% in the group with PCL tears.
Discussion: Most of the articles selected for our review provided level III or IV evidence. Functional outcomes were satisfactory but less good than those reported after surgical reconstruction of isolated cruciate ligament tears. Full reconstruction seems the best strategy in patients with combined ACL/posterolateral corner injuries. Outcomes were also good but more variable in the group with PCL/posterolateral corner injuries. The time to surgery, which reflected the time to diagnosis, was shorter in patients with ACL than with PCL tears in addition to the posterolateral corner injury.
Level of evidence: Level III (systematic literature review).

1. Introduction

Injuries to the posterolateral corner of the knee occurring in isolation or in combination with injuries to the central pivot are uncommon. Posterolateral corner lesions have been estimated

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to occur in 9.1% of acute knee injuries with haemarthrosis and 16% of all knee ligament injuries [1]. The diagnosis is usually missed at the time of the accident. The main structures that make up the posterolateral corner of the knee are the lateral collateral ligament, popliteus tendon, popliteo-fibular ligament, and lateral knee capsule [2]. Biomechanical studies have established that injuries to the posterolateral corner of the knee worsen the deleterious effects of tears in one or both cruciate ligaments [3–5]. A posterolateral corner injury that is not taken into account in the initial treatment strategy increases the risk of failure of procedures to reconstruct the central knee structures [6].

Published data are difficult to assess, as most studies pooled patients with injuries to multiple medial and lateral ligaments [7], chronic and acute injuries [8], and/or one and both cruciate ligaments [9].

Here, our objective was to perform a systematic review of studies reporting the outcomes of surgery for combined injuries to the posterolateral corner and to either the anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL), excluding bicruciate injuries. We assessed both the prognosis and the functional outcome.

2. Material and methods

In June 2014, we searched PubMed, Medline, the CINAHL, the Cochrane Database, Embase, and Google Scholar, with no date limits. We used the following indexing terms: 'posterolateral corner', 'posterolateral corner and ACL', posterolateral corner and PCL', and 'posterolateral corner and high tibial osteotomy'. Two of us (R.G. and A.M.), working independently of each other, used the titles and abstracts to select articles that answered our research question. Selected articles were read in their full-length version, and their reference lists were searched manually for additional relevant publications. We selected only articles in French or English. Inclusion criteria were a follow-up duration of 1 year or more, surgery for a combined injury to the posterolateral corner and to one of the cruciate ligaments, a functional evaluation using one or more functional scores (e.g., IKDC and Lysholm scores), evaluation of rotational instability using the dial test at 30° and 90°, objective evaluation of differential knee laxity, and radiological evaluation. We excluded studies in which patients were followed up for less than 1 year, had medial and lateral multiligamentous injuries or bicruciate injuries, or received only non-operative treatments. We also excluded strictly technical articles.

Of 430 retrieved articles, 392 were excluded because they failed to meet our selection criteria (technical articles, language other than French or English, and articles on surgical anatomy or providing no clinical data). At the second selection step, 25 studies were eliminated because they chiefly included patients with bicruciate injuries. Fig. 1 is the article selection flowchart.

3. Results

Only 13 articles met our selection criteria. Among them, four reported studies of combined ACL and posterolateral corner injuries [10–13] and nine studies of combined PCL and posterolateral corner injuries [14–22]. These 13 studies included a total of 390 patients with a mean age of 32 years. Mean time from injury to surgery was 16 months and mean follow-up after surgery was 37 months (range, 16–120 months).

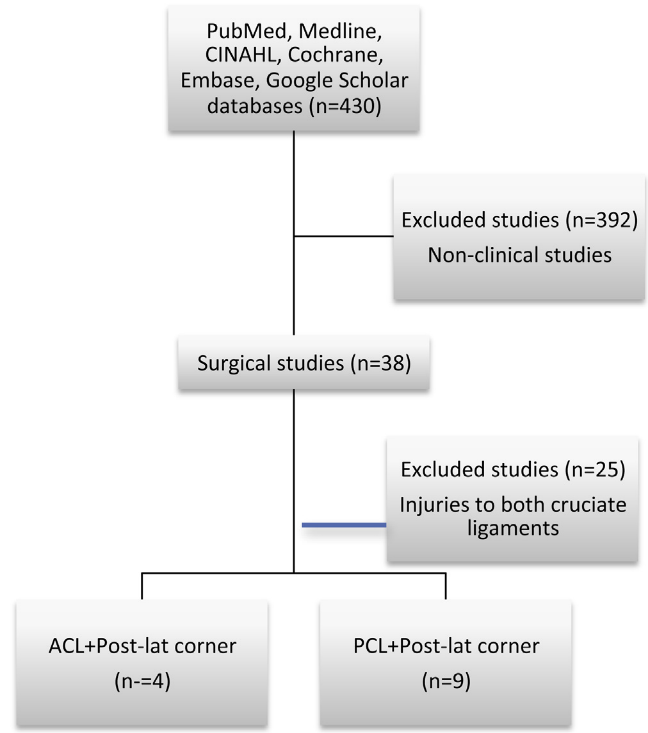

Fig. 1. Flow-chart depicting the number of studies identified, included, and excluded, with the reasons for exclusion.

3.1. Combined anterior cruciate ligament (ACL) and posterolateral corner injuries (four studies)

3.1.1. Level of evidence

None of the studies provided level 1 evidence. Evidence was level 2 for two studies with a comparative prospective design and level 4 for two studies with a retrospective non-comparative design.

3.1.2. Patients

The four studies included a total of 90 patients, 70 males, 11 females, and 9 patients of unspecified gender (Table 1). Mean age at surgery was 27.5 years (range, 15–53 years) and mean time from injury to surgery was 4.4 months (range, 0.5–168 months) (Table 1).

Sports were the most common cause of injury (81.5%), followed by motor vehicle accidents (13.1%) then by other causes (5.4%) (Table 1).

The preoperative work-up included an evaluation of coronal varus laxity in extension and in 30° of flexion, the dial test in 30° and 90° of flexion, and the reverse pivot-shift test to assess the injuries to the posterolateral corner. The magnetic resonance imaging (MRI) technique used to assess the posterolateral corner was that described specifically by Ross et al. [10]. Anterior laxity was evaluated using the 20° anterior drawer test. Dynamic radiographs were obtained in three studies [10,11,13]. The posterolateral corner injuries were grade III in the classification developed by Hugston et al. [23] or Fanelli et al. [24].

3.1.3. Treatment

The posterolateral corner lesions were managed surgically in three studies [10,11,13] and conservatively in one study [12] (Table 2).

There was no consensus regarding the type of transplant or type of reconstruction procedure used to treat the ligament lesions (Table 2). Posterolateral corner reconstruction was achieved using

Table 1
Clinical characteristics of the patients with combined anterior cruciate ligament and posterolateral corner injuries.

Authors	Year	Patients *n* (M/F)	Age, years	Mean follow-up, months	PLC grade	Concomitant lesions	Exclusion criteria	Mechanism	Time to surgery
Ross et al. [10]	2004	9 (NR)	NR	30	NR	None	NR	Sports: 9	< 2 weeks
Lee et al. [11]	2010	SB: 28 (25/4) DB: 16 (16/7)	SB: 31 (16–53) DB: 27 (16–42)	SB: 4 (1–144) DB: 7 (1–168)	II Hugston	4 cartilage lesions, 23 meniscal lesions	PCL, MCL, acute posterolateral corner repair, articular fracture, transplant other than hamstring	Sports: 37, MVI: 5	5 months (1–18 months)
Dhillon et al. [12]	2012	6 (5/1), 8 (8/0)	26.80 (21–36), 25.25 (20–35)	28.33 (14–40), 30.37 (16–44)	6 A, 8 B (Fanelli)	NR	Multiligamentous, revision	NR	NR
Kim et al. [13]	2012	23 (16/7)	36.4 (21–43)	24	NR	NR	Follow-up < 24 months, meniscectomy, axial malalignment > 2°	Sports: 16, MVI: 4	7.8 months (1–30 months)

NR: not reported; SB: single bundle; DB: double bundle; MCL: medial collateral ligament; PCL: posterior cruciate ligament.

a non-anatomic Larson-type method in 44 cases and an anatomic method in 23 cases. The lesions were repaired in 9 cases [10]. In 14 patients, the posterolateral corner lesions were not treated surgically. Most transplants were autologous; a bone-tendon-bone transplant was used in 43 cases and a hamstring transplant in 44 cases. ACL reconstruction was with a single-bundle transplant in 53 cases and a double-bundle transplant in 16 cases; in the remaining cases, the technique was not reported.

3.1.4. Rehabilitation therapy

A single study report, by Kim et al., provided details on the rehabilitation programme [13]. During the first 4 weeks, the patients wore a splint and received ACL rehabilitation therapy. Return to swimming was allowed after 4 months and to other sports after 6 months.

3.1.5. Outcomes at last follow-up

Mean follow-up duration was 34.4 months (range, 14–68 months). Data on function before surgery and at last follow-up were provided in all four study reports (Table 3). After surgery, the IKDC grade was A or B in 81% of patients, whereas 88% of patients had been grade C or D before surgery. The proportion of grade A patients was 47.8%. The subjective IKDC score and Lysholm score were each reported in a single study [12,13]. The mean Lysholm score improved by 15 points, from 77 preoperatively to 90 at last follow-up. The postoperative IKDC score varied from 75 to 87.8.

The available objective data [12,13] showed a 70% gain in comparative anterior laxity. Mean posterior differential laxity decreased from 6.2 mm preoperatively to 1.8 mm postoperatively. The IKDC grade was A in 92% and B in 8% of cases. Only two of the four reports specify the improvements in varus laxity [10,13]. Mean varus laxity was greater than 5 mm in 56% of cases preoperatively and 0 in 93% of cases postoperatively. Control of external rotational laxity was assessed in two of the four studies [11,13]. Correction was noted in 36% of cases, over-correction in 25% of cases, and under-correction in 39% of cases.

3.1.6. Complications

Two of the four study reports provided data on complications. The complication rate was 10%. Stiffness requiring arthroscopic arthrolysis developed in 2 patients [11] and range-of-motion limitation in 3 patients (limited flexion in 1 patient and limited extension in 2 patients). Thus, the frequency of stiffness was 5.5%. The other complications consisted of recurrent ACL rupture in 1 patient, revision surgery for recurrent posterolateral instability in 1 patient, and infections in 2 patients.

3.2. Combined posterior cruciate ligament (PCL) and posterolateral corner injuries (nine studies)

3.2.1. Level of evidence

None of the nine studies provided level 1 or 2 evidence. Three studies were level 3 (comparative retrospective studies) and six were level 4 (non-comparative retrospective studies).

Table 2
Treatments used in the patients with combined anterior cruciate ligament (ACL) and posterolateral corner injuries.

		ACL tear				Posterolateral corner injury	
Authors	Year	Treatment	Transplant	Degree of fixation	Type of fixation	Treatment	Type of fixation
Ross et al. [10]	2004	Reconstruction	BTB	NR	NR	NR	NR
Lee et al. [11]	2010	Reconstruction	Hamstring	NR	Rigidfix, staple	Larson	Resorbable screws
Dhillon et al. [12]	2012	Reconstruction	BTB	NR	Rigidfix, endobutton, staple	Conservative	NR
Kim et al. [13]	2012	Reconstruction	BTB	10–15%	Resorbable screws	Anatomic reconstruction	Resorbable screws

NR: not reported; BTB: bone-tendon-bone transplant.

Table 3
Outcomes in the group with combined injuries to the anterior cruciate ligament and posterolateral corner.

Authors	Year	Clinical scores	Anteroposterior laxity	External rotation	Laxity in varus	Anteroposterior laxity	Laxity in varus	Radiographs	Complications
Ross et al. [10]	2004	IKDC: 3 A/B, 6 C/D	NR	NR	5/9: varus 1+	NR	NR	NR	NR
Lee et al. [11]	2010	Pre-op vs. post-op SB: A: 0/16, B: 2/9; C: 6/2; D: 20/1 DB: A: 0/9; B: 1/5; C: 3/2; D: 12/0	35/44 grade 0 9/44 grade I	41/44 grade 0, 3 grade 1		KT1000 pre-op vs. post-op SB: 6.1 ± 1.7; 1.5 ± 0.9 DB: 5.6 ± 1.4; 1.6 ± 1.8 Rx stress: SB 6.6 ± 1.6; 1; 1.5 ± 0.9; 7.6 ± 2.5; 1.3 ± 1.3	Pre-op vs. post-op: SB: 2.1 ± 1.7; 0.4 ± 0.7; 1.3 ± 1.7; 0.4 ± 1	NR	2 arthrolysis, 1 ACL rupture (18 months), 2 infections
Dhillon et al. [12]	2012	Type A: IKDC = 87.8; Type B: IKDC = 75	6/8 normalisation of Lachman's test	NR	NR	NR	NR	NR	NR
Kim et al. [13]	2012	IKDC 6A, 14B, 2C, 1D Lysholm: 90.1 ± 7	Normalisation Of the pivot-shift test, 22 Of Lachman's test, 21	19 contralateral knee; 3 < 10°; 1 > 10°; SSD dial test 30: 4.8°; dial test 90: 3.2°	2/24: scored 1+	KT 1000, SSD: 1.6 ± 0.8 mm, 21 < 3 mm, 2 between 3 and 5 mm	Stress X-rays: SSD: 0.5 ± 0.7; 21 < 3 mm, 2 between 3 and 5 mm	1/24 progression to osteoarthritis	1 flexion deficit > 5°, 2 extension deficit > 5°, 1 revision for posterolateral corner instability

SB: single bundle; DB: double bundle; IKDC: International Knee Documentation Committee score; NR: not reported; SSD: side-to-side difference.

3.2.2. *Patients*

The nine studies included 300 patients, 246 males and 54 females (Table 4) with a mean age at surgery of 31.1 years (range, 15–65 years) and a mean time from injury to surgery of 18.4 months (range, 2–105 months) (Table 4).

The injury was related to a motor vehicle or sports-related accident in 60% of cases and to other causes in 40% of cases (Table 4).

The preoperative work-up included testing for coronal varus laxity in extension and in 30° of flexion, the dial test in 30° and 90° of flexion, and the reverse pivot-shift to assess the posterolateral

Table 4
Clinical characteristics of the patients with combined posterior cruciate ligament (PCL) and posterolateral corner injuries.

Authors	Year	Patients *n* (M/F)	Mean age, years	Mean follow-up, months	PCL grade	Concomitant lesions	Exclusion criteria	Mechanism	Time to surgery, months
Wang et al. [14]	2002	25 (16/9)	28	40 (32–60)	III	None	NR	RTA: 22, sports: 3	10 (2–24)
Fanelli et al. [15]	2004	41 (31/10)	NR	24–120	III	None	NR	NR	NR
Khanduja et al. [16]	2006	19 (18/1)	29.6 (21–47)	66.8 (24–110)	III	None	NR	RTA: 4, sports: 15	27.3 (3–105)
Jung et al. [17]	2008	39 (34/5)	33.5 (15–59)	35.3 (24–70)	III	None	28 (LCL ligamentoplasty repair, ACL surgery, MCL surgery, concomitant bone lesions)	RTA: 24, sports: 11	10.4 (± 4.7)
Wajsfisz et al. [18]	2010	21 (13/8)	26.8 (18–40)	22.6 (12–53)	III	None	Follow-up < 1 year	RTA: 13, sports: 7	18.9 (8–47)
Kim et al. [19]	2011	42 (34/8)	30.7 (22–46)	47.85 (24–70)	III	None	NR	RTA: 9, sports: 24	NR
Lee et al. [20]	2011	70	31.2	40.1 (24–96)	III	None	Yes	NR	23.7
Kim et al. [21]	2013	24 (17/7)	40.3 (14–65)	35.4 (24–47)	III	None	Revision, concomitant fracture, bony avulsion, malalignment > 5°, grade 3 cartilage lesion, total meniscectomy, lesions in addition to the PCL and posterolateral corner, follow-up < 24 months	RTA: 10, sports: 4	27.3
Zorzi et al. [22]	2013	19 (13/6)	29 (17–41)	38 (± 12.3)	III	None	ACL, dynamic varus, radiological varus, fibular nerve palsy, osteoarthritis	RTA: 12, sports: 7	11 ± 9.3 (± 2 SD)

NR: not reported; LCL: lateral collateral ligament; RTA: road traffic accident; ACL: anterior cruciate ligament; MCL: medial collateral ligament.

Table 5
Treatments used in the patients with combined posterior cruciate ligament and posterolateral corner injuries.

		Posterior cruciate ligament				Posterolateral corner		
Authors	Year	Treatment	Transplant	Degree of fixation	Type of fixation	Transplant	Degree of fixation	Type of fixation
Wang et al. [14]	2002	DB reconstruction	NR	NR	NR	DB PCL, popliteus to fascia lata or anterior 1/3 of biceps femoris and advancement capsuloplasty for the LCL	NR	NR
Fanelli et al. [15]	2004	SB reconstruction	Achilles tendon allograft	NR	NR	Biceps femoris tenodesis	NR	NR
Khanduja et al. [16]	2006	SB reconstruction	Achilles tendon allograft: 16 Autologous: 3	NR	Interference screw	Larson	NR	NR
Jung et al. [17]	2008	SB reconstruction	Hamstring tendon graft	70°	Resorbable interference screw	HT 14; Achilles tendon allograft: 5		NR
Wajsfisz et al. [18]	2010	DB reconstruction	BTB 4, QT 17	NR	NR	Larson/Muller; 3 HTO: 3	NR	NR
Kim et al. [19]	2011	SB reconstruction: 23; DB reconstruction: 19	Achilles tendon allograft: 23 Tibialis posterior tendon allograft: 19	70°	Bioscrew	Tibialis posterior tendon allograft (anatomic)	NR	Resorbable screws
Lee et al. [20]	2011	NR	NR	NR	NR	NR		
Kim et al. [21]	2013	SB reconstruction	Achilles tendon allograft	NR	Interference screw	Tibialis posterior tendon allograft (anatomic)	NR	Resorbable screws Endopearl
Zorzi et al. [22]	2013	SB reconstruction	Tibialis anterior tendon allograft	70°	BioRCI	Allograft	30°	BioRCI

SB: single bundle; DB: double bundle; NR: not reported; BTB: bone-tendon-bone transplant; LCL: lateral collateral ligament; HTO: high tibial osteotomy; QT: quadrcipital tendon; BioRCI: BioRCI interference screws.

corner lesions. Posterior laxity was assessed by performing the posterior drawer test in 70° of flexion, in most cases with the classification developed by Clancy et al. [23]. A single study, by Zorzi et al. [22], detailed the MRI evaluation. A dynamic radiographic evaluation (varus views and/or Telos imaging) was described in detail in six study reports [15,17–19,21,22]. All posterolateral corner lesions were grade III in the classification developed by Hugston et al. [24] or Fanelli et al. [25].

3.2.3. *Treatment*

In all nine studies, the posterolateral corner lesions were treated surgically (Table 5). There was no consensus about the strategy used to treat the ligament lesions, in terms of either the type of transplant or the type of procedure (Table 5). Reconstruction of the posterolateral corner was usually achieved by performing an 'anatomic' procedure [17,19,21,22]. Allografts were used predominantly and consisted chiefly in an Achilles tendon or tibialis posterior tendon [17,19–22]. PCL reconstruction was with a single-bundle transplant (anterolateral) in 165 cases and a double-bundle transplant in 65 cases.

3.2.4. *Rehabilitation therapy*

The rehabilitation programme was detailed in only seven of the nine study reports [16–19,21,22]. In most cases, an extension splint was used for 8 days to 3 weeks then a hinged splint for 3 weeks. In a single study, by Zorzi et al. [22], the duration of immobilisation was only 2 weeks. Immediate weight bearing was allowed in one study [16], whereas time to weight bearing was 4 weeks in one study [21] and 6 weeks in another [17]. The return to sporting activities was allowed only after 6 months [19] to 9 months [16,21]. The time to complete discontinuation of splint immobilisation was not specified in all the reports; it was 10–12 weeks in the study by Kim et al. [21].

3.2.5. *Outcomes at last follow-up*

Mean follow-up duration was 40.7 months (range, 12–120 months). Eight of the nine study reports provided preoperative and postoperative functional data (Table 6). Postoperatively, the IKDC grade was A or B in 81% of patients, whereas 99% of patients were grade C or D before surgery. Objective preoperative and postoperative evaluations were reported for eight of the nine studies (Table 6). The mean Lysholm score increased by 24 points, from 65 preoperatively to 89 at last follow-up. The mean Tegner score improved from 2.6 to 4.9 and the mean IKDC score from 50.8 to 88.7.

All nine study reports provided at least some objective data on outcomes. The gains in comparative posterior laxity ranged from 28% to 79%. Mean differential posterior laxity improved from 9.3 mm preoperatively to 2.4 mm postoperatively. Mean improvement in varus laxity was 72% (range, 63–91%) in the five studies

Table 6
Outcomes in the group with combined injuries to the posterior cruciate ligament and posterolateral corner.

		Clinical evaluation				Objective evaluation			
Authors	Year	Clinical scores	Anteroposterior laxity	External rotation	Varus laxity	Anteroposterior laxity	Varus laxity	Radiographs	Complications
Wang et al. [14]	2002	Lysholm 64 vs. 86; IKDC 7 A, 10 B, 5 C, 3 D; Tegner 3.72	A: 11; B: 9; C/D: 5	3.5 vs. 15 pre-op	D = 25 vs. A 11, B 10, C/D 4	Mean 10.1 vs. 2.2 mm	Mean 11.4 vs. 3.6	38% with signs of osteoarthritis within 2 years and 44% after 2 years	NR
Fanelli et al. [15]	2004	Lysholm: 65.48 vs. 91.7, Tegner: 2.71 vs. 4.92; HSS: 50.82 vs. 88.7	Pre-op: 33 D, 8 C vs. 29 A, 11 B, 1 D	41 D > 10 vs. A (29 < 0, 11 = 0), 1 D > 10	Normal 30°: 40/41	Telos: 2.26 mm, KT1000: 4.64 vs. 1.80		NR	NR
Khanduja et al. [16]	2006	IKDC: 19 D then 6 A, 11 B, 2 C, 0 D; Tegner 2.6 (1–4) vs. 6.4 (4–9); Lysholm: 41.2 (28–53) vs. 76.5 (57–100)	19 D vs. 7 A, 11 B, 1 C	19 D vs. 14 A, 5 B	19 D vs. 14 A, 5B	0: 7; grade I: 11; grade II: 1	14 none, 2 minimal	NR	7 revisions for screw removal, 2 manipulations, 2 superficial infections
Jung et al. [17]	2008	IKDC: 16 C, 23 D vs. 10 A, 22 B, 6 C, 1 D; Obj. IKDC 84.6 ± 11.1; 82.1 ± 11.5	NR	Failure 7/18	A: 35, B: 3, C: 1	KT1000: 10.4 ± 2.1 vs. 2.1 ± 1.1 mm (10.1 ± 2.7 vs. 2.2 ± 0.9 mm) Stress view: 10.4 ± 2.1 vs. 2.1 ± 1.1; 10.1 ± 2.7 vs. 2.2 ± 0.9	29 same as normal side	NR	NR
Wajsfisz et al. [18]	2010	IKDC: 3 A, 10 B, 7 C, 1 D	IKDC 4 A, 11 B, 6 C	11 ER < 10°	NR	Telos 90°: 1.7 (−9/12)	NR	NR	2 arthrolyses
Kim et al. [19]	2011	SB: Lysholm 60.1 ± 11 vs. 85.7 ± 7.6 IKDC: 11 C, 12 D vs. 4 A, 12 D, 5 C, 2 D; DB: Lysholm 58.2 ± 12.2 vs. 87.7 ± 7.3; IKDC 8 C, 11 D vs. 3 A, 11 B, 4 C, 1 D	SB: A/B: 19, C/D: 3 DB: A/B 19, C/D 4	DT 30° SB 5.3 ± 2.7°; DB 5.1 ± 2.4° DT 90° SB 6.7 ± 2.7°; DB: 6.7 ± 2.4°		Laxity > 5 mm SB: 22%; DB: 21%	SB: 1.2 ± 1.2 DB: 1.3 ± 1.4 mm	NR	NR
Lee et al. [20]	2011	IKDC: 42 C and 28 D vs. 30 A, 34 B, 8 C, and 6 D	Post-op: 40 A, 26 B, 4 C	70 > 10° vs. 14 < 0°, 50 = 0°, 6 < 10°	70 > 15° vs. 68 = 0, 2 < 5°	10.3 ± 2.4 to 2.2 ± 1.5 KT 1000: 8.4 ± 2.2 mm to 2 ± 1.4 mm	70 > 15° vs. 68 = 0, 2 < 5°	NR	
Kim et al. [21]	2013	Lysholm: 23.42 ± 7.44; IKDC 20 C, 4 D vs. 12 A, 9 B, 3 C	(−1.44 ± 0.74)	DT30° 4.04 ± 1.3° DT90° 3.67 ± 1.37°	1.35 ± 1	5.02 ± 0.85 vs. 3.58 ± 0.5	5.01 ± 1.3 vs. 1.35 ± 1	NR	NR
Zorzi et al. [22]	2013	Tegner: 2 (1–4) to (4–9); IKDC: 3 > 86	14 grade 0; 5 grade I	17: 0, 2 positive	17: 0, 2 positive	Differential 0–2 mm: 14, 3–5 mm: 5		Grade 2: 2	None

SB: single bundle; DB: double bundle; IKDC: International Knee Documentation Committee evaluation; HSS: Hospital for Special Surgery knee score; NR: not reported; DT: dial test.

reporting this parameter [16,17,19–21]. Mean varus laxity was greater than 10 mm in 74% of cases preoperatively, whereas no varus laxity was present postoperatively in 85% of cases. Control of external rotational laxity was evaluated in six of the nine studies. The results showed correction in 52% of cases, over-correction in 38% of cases, and under-correction in 10% of cases.

Only Kim et al. provided details on the return to previous activities [19]. Of their 41 patients, 23 were able to return to very strenuous sports (football) and/or occupational activities and 9 to strenuous sports (ski or tennis); the remaining 10 patients engaged in moderately strenuous sports (running). No patient had activities confined to those of daily living.

3.2.6. Complications

Only 5 cases of stiffness requiring manipulation or arthrolysis were reported [16,18]. Secondary osteotomy was performed in 6 patients to treat persistent varus laxity [18].

4. Discussion

We are aware of a single previous literature review evaluating the outcomes of combined injuries to the ACL and posterolateral corner, by Bonanzinga et al. [26], and of none on combined injuries to the PCL and posterolateral corner. Our findings support those reported by Bonanzinga et al. [26] regarding the paucity of published data. Since the publication of their review, no study has provided high-level evidence on the outcomes of surgery to treat combined injuries to the ACL and posterolateral corner. Similarly, we found no source of high-level evidence on the surgical treatment of combined PCL/posterolateral corner injuries. This scarcity of data is partly ascribable to the relatively low frequency of posterolateral corner injuries, whose incidence has been reported to range from 2% to 5% in specialised centres [1,27], and in part to the high frequency of associated multiligamentous lesions, which complicate the interpretation of the results [1]. The heterogeneity of published studies in terms of both the management strategies and the evaluation methods also limits the validity of the conclusions that can be drawn from our work. The limitation related to the absence of objective tools for evaluating the various components of knee laxity, most notably in rotation, was also pointed out by Bonanzinga et al. [26]. The potential severity of injuries that involve both the posterolateral corner and the ACL or PCL is well established [4,5,28,29]. Failure to take posterolateral corner lesions into account is also a known cause of failure of isolated cruciate ligament reconstruction in patients with combined injuries [21,26]. In our review, both the overall outcomes and the outcomes in each of the two groups (ACL/posterolateral corner and PCL/posterolateral corner) seem acceptable given the nature of the initial lesions. Thus, when considering the total patient population, the IKDC grade was C or D in 95% of patients preoperatively and A or B in 65% of patients postoperatively. Nevertheless, this leaves 35% of patients with a C or D IKDC grade after surgery, indicating an inadequate outcome. The mean global Lysholm score improved from 67 preoperatively to 90 postoperatively. The objective data on anteroposterior, varus, and rotational laxity before and after surgery showed substantial improvements, which were most marked for varus and rotational laxity. However, these overall results were less good than those usually achieved after isolated ACL or PCL reconstruction, in terms of both functional scores and laxity control [30–33]. The functional outcomes were within the range previously reported to be acceptable to patients [34]. Functional improvements as assessed using the IKDC and Lysholm scores were similar in the ACL/posterolateral corner and PCL/posterolateral corner groups.

In both the ACL/posterolateral corner and PCL/posterolateral corner groups, reconstruction of the central pivot relied chiefly on single-bundle transplants, with a preference for autologous grafts in the ACL/posterolateral corner group and allografts in the PCL/posterolateral corner group. This strategy has also been advocated for isolated reconstruction of the ACL or PCL [35,36].

A wide variety of rehabilitation programs were used, in keeping with previously published data [37,38]. The data from the studies selected for our review suggest that weight bearing should be deferred, particularly in patients with PCL tears, with immobilisation for at least the first 6 weeks and muscle strengthening exercises focussing on the quadriceps and avoiding efforts associated with posterior drawer displacements [38,39].

Our results for the group with ACL/posterolateral corner injuries are consistent with those reported by Bonanzinga et al. [26], although differences occurred in the studies selected for the two reviews. Thus, we selected neither the article by LaPrade et al. [40], which was a case-report, nor the article by Latimer et al. [41], in which the lesions were extremely heterogeneous.

The best outcomes were achieved with combined reconstruction of the ACL and posterolateral corner. The results in terms of laxity (mean differential, 1.5 ± 1.1 mm) were comparable to those reported after isolated ACL reconstruction [20]. The functional outcomes observed with this strategy were better than those obtained after ACL reconstruction and posterolateral corner repair. The poorest outcomes occurred in the patients whose posterolateral corner lesions were not treated surgically [10,12].

In the group with PCL/posterolateral corner injuries, the objective and subjective outcomes were good, with significant improvements in functional scores and significant decreases in rotational, posterior, and varus laxities. Nevertheless, the improvement in posterior laxity seems considerable, given that persistent posterior laxity has been reported after isolated PCL reconstruction [42]. The residual posterior laxity varied across studies from 2 to 6 mm and was thus substantially greater than the mean of 2.4 mm noted in our review [43,44]. The mean gain in our study was 73%, compared to only 70% in the group with ACL/posterolateral corner injuries. We find these data somewhat surprising. The study reports do not provide details on the methods used to measure posterior laxity before and after surgery. Failure to standardise the degree of rotation can bias the measurements [45]. Before surgery, posterior laxity can be increased by the presence of posterolateral corner lesions if the excess external rotation is not reduced [3–5]. The wide variability in gains, from 28% to 79%, confirms that posterior laxity is more difficult to control than is anterior laxity.

Mean time to treatment was 4.43 months in the group with ACL/posterolateral corner injuries compared to 19 months in the group with PCL/posterolateral corner injuries. These longer values compared to the usual times to treatment in patients with isolated injuries to the central pivot can be ascribed to failure to diagnose posterolateral corner lesions, which are uncommon [1]. Posterolateral corner lesions should be sought routinely, as they may be present in 43% to 80% of patients but may frequently escape detection [46]. Treatment delays have also been reported in patients with 'isolated' PCL tears and result in poorer outcomes compared to 'isolated' ACL tears [47].

Regarding the long-term prognosis and, more specifically, the risk of progression to osteoarthritis, no conclusions can be drawn from the studies included in our review. A single study reported short-term outcomes (after 2 years) [14]. However, several other studies, characterised by greater heterogeneity of their patient populations, show that the good outcomes in terms of stability fail to translate into a decrease in the frequency of osteoarthritis, or at least of radiological osteoarthritis, which has been estimated at 23% [48].

5. Conclusions

Combined injuries to the ACL or PCL and to the posterolateral corner require surgical treatment. Combined reconstruction provides the greatest likelihood of achieving acceptable functional outcomes. Among patients with posterolateral corner injuries, those with PCL tears have poorer outcomes than do those with ACL tears. There is no consensus regarding the best reconstruction strategy or rehabilitation programme. Earlier recognition of posterolateral corner lesions is needed to attempt to improve the prognosis of these combined injuries. None of the studies published to date provides conclusions regarding the long-term outcomes.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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